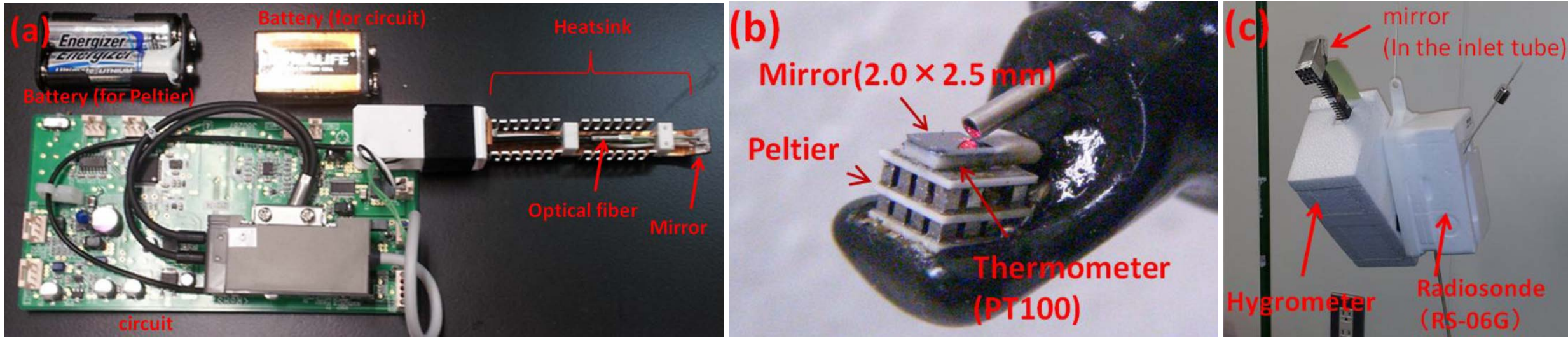


Japanese non-cryogen frost-point hygrometer:

A Peltier-based, digitally controlled chilled-mirror hygrometer for radiosonde sounding



- Takuji Sugidachi, Ph.D thesis, Hokkaido University, March 2014
- Collaboration among Hokkaido University, Azbil Corporation, and Meisei Electric Co. Ltd.
- The sensor probe of **Azbil's "FINEDEWTM"** instrument (for industry use) is used.
- The digital PID^{*1)} controller and the interface to Meisei RS-06 radiosonde were developed, and the PID parameters were tuned for atmospheric balloon sounding in Japan and in Indonesia (with 9 test flights during 2011-2013).
- A commercial version is being developed at Meisei (2017).

*1) PID: proportional–integral–derivative

Japanese non-cryogen frost-point hygrometer:

Motivation and History

- A chilled-mirror hygrometer for radiosounding, without cryogen material.
- Meteolabor **Snow White** hygrometer is a Peltier-based, analog-controller hygrometer – its stratospheric performance was not satisfactory (Fujiwara et al., JTECH, 2003).
 - Due to limited cooling ability of the Peltier (electric cooling) device?
 - Or, due to its analog controller? [**NOAA FPH** to **CFH** transition in the early 2000s showed many advantages of a digital controller.]
- 2004-2006: Hokkaido University supported Azbil (then Yamatake) Corporation to develop their **FINEDEW™** instrument as a “tenth project” (i.e., making a small instrument).
- 2009-2012: Takuji Sugidachi led the “Japanese frost-point hygrometer” project as his Ph.D thesis.



Azbil FINEDEW™ FDW10



1st JP-FP sonde



4th JP-FP sonde



7th JP-FP sonde

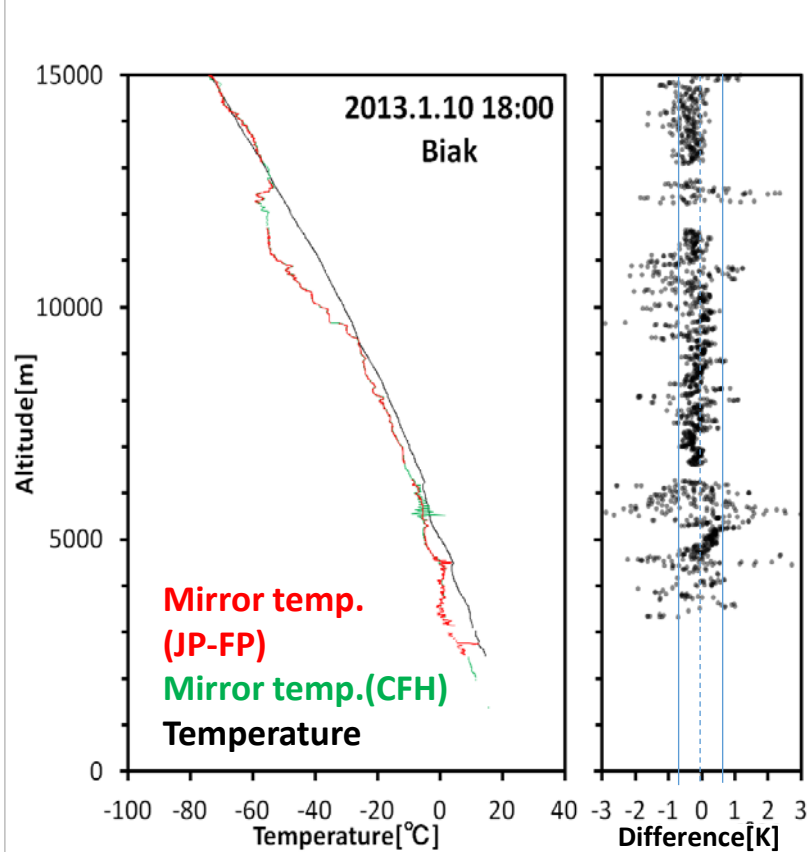


9th JP-FP sonde

Japanese non-cryogen frost-point hygrometer:

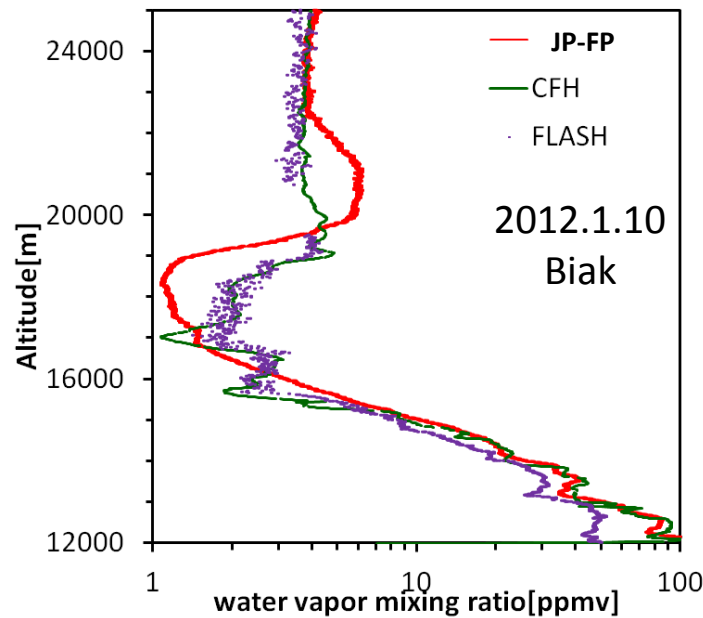
Results from soundings – 3 cases at Biak, Indonesia

(1) Tropospheric comparison with CFH



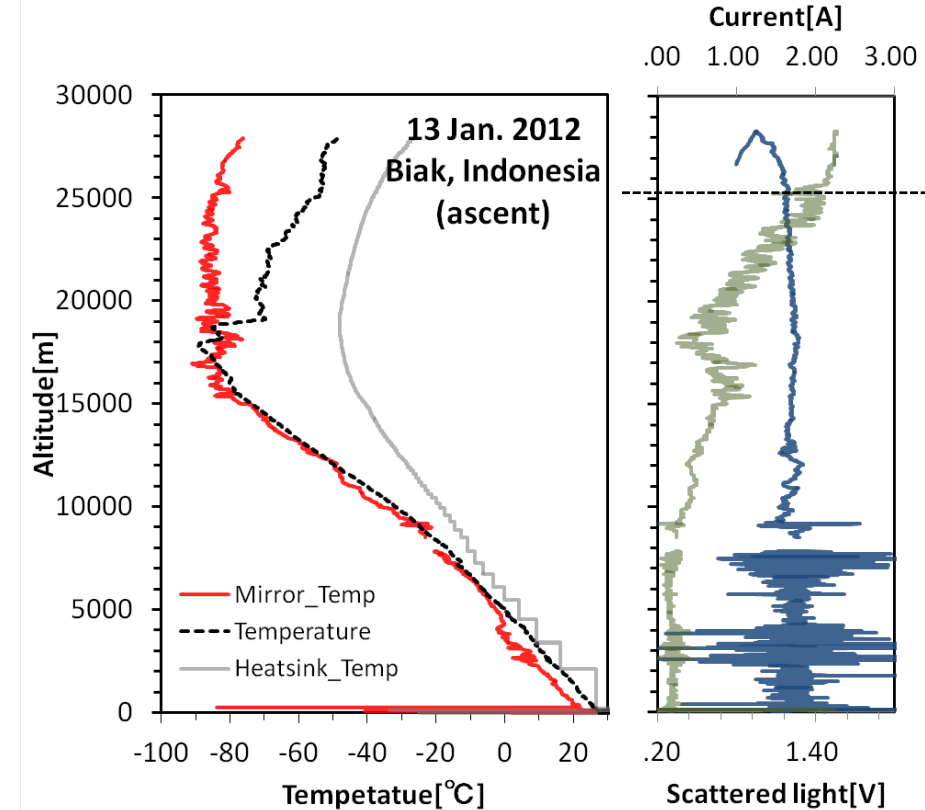
→ Agrees well with CFH within ± 0.5 K

(2) Lower stratospheric comparison with CFH and FLASH-B



→ JP-FP's response is slow ...
More PID tuning?
Condensates on the mirror?

(3) More PID tuning



→ PID parameters were tuned more actively, and the measurements are good (i.e., stable scattered light signal) up to ~25 km

Japanese non-cryogen frost-point hygrometer:

Summary and future plans

- A Peltier-based chilled-mirror hygrometer for radiosounding was developed, aiming at e.g., climate monitoring.
- A dedicated digital controller was developed from a scratch.
- The results from 9 test flights in Japan and in Indonesia indicated that lower stratospheric water vapor measurements would be technically possible without using cryogen material.
- (An additional cooling device for the Peltier hot-side was also developed, to address the limited cooling ability of the Peltier device.)
- Takuji Sugidachi moved to Meisei in 2013, working on development of radiosondes and special instruments for radiosounding.
- He will produce a preliminary, commercial version this year.
- He will follow the XDATA protocol by NOAA.

Japanese non-cryogen frost-point hygrometer:

Motivation and History

- A chilled mirror hygrometer for radiosounding, without cryogen material.
- Meteolabor **Snow White** hygrometer is a Peltier-based, analog-controller hygrometer – its stratospheric performance was not satisfactory.
 - Due to limited cooling ability of the Peltier (electric cooling) device?
 - Or, due to its analog controller? [**NOAA FPH** to **CFH** transition in the early 2000s showed many advantages of a digital controller.]
- 1998: A tropical Pacific project **SOWER** started, by collaborating with NOAA for **NOAA FPH** soundings at Galapagos and later at Indonesia.
- 2000-2001: Fujiwara et al. extensively used Meteolabor **Snow White** (a Peltier-based, analog-controller) hygrometer in the tropical Pacific.
- 2003: Holger Vömel developed **CFH**, and SOWER started to use it . . . [See e.g., Fujiwara et al. (JGR, 2010; <http://doi.org/10.1029/2010JD014179>)]
- (2008: SOWER also started to test **FLASH-B** hygrometer.)
- 2004-2006: Hokkaido University supported Azbil (then Yamatake) to develop their **FINEDEW**TM instrument.
- 2009-2013: Takuji Sugidachi led the “Japanese frost-point hygrometer” project as his Ph.D thesis.